ABSTRACTS FROM ASTRONOMICAL PUBLICATIONS.

In accordance with a recent arrangement the members of the scientific staff of the Lick Observatory hold meetings once per week, as an observatory duty, to report upon and discuss the more important articles appearing in the journals of astronomy, the important new books on astronomical subjects, or subjects of current and special interest in the observatory's work. It has been suggested that abstracts of the reports would be of interest to the readers of these Publications, and the Publication Committee has acted favorably upon the suggestion.

It is intended to preserve the qualities of abstracts as far as possible, and to restrict published criticisms, favorable or unfavorable, to a minimum.

ABSTRACT OF SOME RECENT RESULTS IN THE MOTION OF THE SOLAR SYSTEM AND THE SYSTEMATIC MOTIONS OF THE STARS.

It was good fortune which appointed LEWIS BOSS, now director of the Dudley Observatory, Albany, as assistant to the U. S. Boundary Commission, whose duty it was, in conjunction with a similar British commission, to define the boundary-line at the forty-ninth parallel of north latitude between the United States and Canada, in the years 1872-75. Professor Boss concluded that the resulting latitudes of the twenty-two stations lying very close to the forty-ninth parallel were not significantly in error from instrumental and observational causes, but that somewhat larger errors could be ascribed to systematic errors in the declinations assumed for the stars observed. Professor Boss's researches on the declinations of the latitude stars were extended to include all of the stars then in the American Ephemeris. The results were published as a catalogue of definitive declinations of 500 stars for the epoch 1875.0. The extensive uses to which this catalogue has been applied in the past thirty-five years have shown that Professor Boss exercised remarkably good judgment in the weighting of the observations and in the methods adopted for eliminating systematic errors.

Professor Boss's activity in the determination of star positions as free as possible from systematic error has continued to the present time almost without interruption. By virtue of his efforts, assisted financially in recent years by the Carnegie

Institution of Washington, he published in 1910 his "Preliminary General Catalogue of 6,188 Stars, for the Epoch 1900," with their proper motions in right ascension and declination. The catalogue includes all stars down to the sixth visual magnitude, together with more than two thousand stars, mostly contained between the magnitudes 6.0 and 7.5, for which the proper motion can be determined with more than average accuracy. It is not our purpose to review this monumental work, but to give in abstract a few of the results [1] which Professor Boss and others have recently deduced from the data of this catalogue, as to the motion of the solar system through space, and as to certain apparent peculiarities in the motions of the stars. Many notable contributions to these problems have been made in earlier years, essentially all based upon the proper motions of brighter stars. The proper motions deduced by Professor Boss are undoubtedly of a higher order of excellence than those assigned to the stars by any other catalogue; for every available resource was utilized to the uttermost in the elimination of systematic errors. The solutions of stellar problems based upon these proper motions, if made with circumspection, acquire merit correspondingly higher than that of earlier solutions of the same problems based upon inferior data.

In solving for the solar motion Professor Boss rejected stars whose proper motions exceeded certain limits, and which might therefore represent abnormally large linear motions, or nearness to the solar system, or both. He likewise utilized only one star to represent a double or triple star, and in the several cases of groups of stars traveling with equal velocities along parallel lines he selected from one to four stars to represent each group. There remained as available for the main solution 5,413 stars. Of these, 3,549 are of the sixth magnitude or brighter, with mean magnitude 5.2. The remaining 1,864 stars, below the sixth magnitude, had average brightness 6.7.

The entire sky was divided into 108 areas, each containing approximately 400 square degrees, each area containing on the average about fifty stars. He assumed, in effect, that the stars are moving at random through space, having no preference for one direction rather than another, not as something proved but

[1] *Astronomical Journal*, Nos. 612 and 614.

as something to be tested. In order that the extremely troublesome factor, the distances of the stars, might be ignored, it was assumed that the proper motions are, in general, functions of the stellar distances from the solar system, and that the stars are grouped systematically in space with reference to the solar system.

The means of the proper-motion components in right ascension and declination, respectively, of all the stars in a given area were formed, and were considered as attaching to an average or representative star at the center of each area. The usual equations of condition governing the effect of solar motion upon the proper motions of the stars were extended so as to include corrections to the precession constants which had entered into the computation of the proper motions in the first place. When the individual equations were combined into normal equations, it was found that the solution took a very definite form, in that each unknown quantity was quite independent of every other; that is, that the elements of the solar motion to come out of the solution would be essentially independent of the adopted values of the precession constants.

A solution based upon the proper motions of the 5,413 stars of average brightness 5.7 magnitude gave the following position of the apex of the Sun's way:—

$$\begin{aligned} \text{R. A.} &= 270^\circ.5 \pm 1^\circ.1 \text{ to } 1^\circ.5, \\ \text{Dec.} &= +34\ .3 \pm 0\ .9 \text{ to } 1\ .3; \end{aligned}$$

and the speed of the solar motion was found to be such that it would cause a drifting of an average star of the entire group, if located 90° from the apex of the Sun's way, amounting to 3″.85 in a century.

Another solution was based upon the 3,549 stars which were brighter than the sixth magnitude. The corresponding quantities were,—

$$\begin{aligned} \text{R. A.} &= 269^\circ.9, \\ \text{Dec.} &= +34\ .6; \end{aligned}$$

and centennial drift at 90° from the solar apex, 3″.99 for the average star of the group.

Another solution was based upon the 559 stars which had not been used in the main solution because of their very large

proper motions. The position of the apex deduced from them is,—

R. A. = 272°.0,
Dec. = +34 .5;

and centennial drift for an average star of this group, of 21″.58.

The small range exhibited in the results for the apex is very satisfactory, and gives confidence that improvements in our knowledge of the direction of the motion of the solar system, as determined from proper motions, will not be sensibly improved for many years to come.

Professor Boss has endeavored to determine the linear velocity of the Sun's motion from a co-ordination of observed proper motions and observed stellar parallaxes. He is of the opinion that the velocity of 24^{km} per second, deduced from his computations, is a useful constant for the present. If I may here depart from abstract of results to friendly criticism, I am disposed to question the usefulness of this result; my skepticism being based not upon the correctness of the proper motions nor upon the skill and faithfulness with which the processes of solution have been carried through, but upon the unavoidable limitations of existing parallax data. The number of accurately determined parallaxes in the first place is small, but the weakness of the solution comes chiefly from the non-representative character of stars whose parallaxes have been determined. In nearly all cases, parallax observers have formed their observing programs upon special and exceptional conditions, the chief of which is large proper motion. It must prove that abnormally large proper motions result on the average from abnormally large linear velocities (at right angles to the line of sight) as well as from closeness to the solar system. If parallax stars have been observed for special reasons and are not representative of the stellar system in general, we have no present means of determining the velocity of the solar system from them. My solution of January, 1910, for the velocity of the solar motion, based upon the observed radial velocities of 1,047 objects, is slightly under 18^{km} per second. The velocity adopted by Professor Boss, from proper motion and parallax data, is thirty-five per cent greater.

The proper motion studies of Professor KAPTEYN, about the year 1904, led him to the conclusion that the stars have

two preferential motions of direction. He then formulated the hypothesis that there are two star drifts. A good comprehension of this hypothesis can be obtained thus: Suppose that forty per cent of the stars, more or less, originally formed a great group in which the individual stars were moving at random. Suppose that the remaining sixty per cent, more or less, originally formed another great group whose individual members were moving at random. Suppose, further, that the motions of these two groups as a whole were such that one system interpenetrated the other. We should then have, in effect, a combined system of stars in which the motions would be substantially as KAPTEYN has described. There would be stars moving in all directions, but the motions of one group would have a maximum in a given direction, and the motions of the other group would have a maximum in another direction. It is not a part of KAPTEYN's hypothesis, certainly not as yet, that the stars originally did form two separate groups which have moved toward each other and have interpenetrated, but simply that the observed motions are, in effect, as if such had been the case.

SCHWARZSCHILD has formulated an ellipsoidal hypothesis to cover the observed preferential directions of stellar motions, which is simpler and perhaps fully as satisfactory a working hypothesis as KAPTEYN's two-drift hypothesis. SCHWARZSCHILD's supposition is that the average magnitudes of the stellar motions in different directions may be represented, on the average, by radii drawn from the center of an ellipsoid to the surface of the ellipsoid; the longest axis of the ellipsoid being parallel to the preferential direction of motion of the stars. Six or eight leading astronomers have investigated the proper motion data supplied by various of the more extensive star catalogues, and have come to the conclusion that there is a strongly marked preferential direction of stellar motion substantially in accordance with KAPTEYN's and SCHWARZSCHILD's theories.

Professor Boss has held the subject in mind throughout his studies of the proper motions contained in his Preliminary General Catalogue, and his paper expresses the opinion that the hypothesis of purely "random motion of the stars receives strong support" from his results; in other words, that they do

not indicate a preference of the stars for motion in any special direction.

In the *Monthly Notices* of the Royal Astronomical Society for November, 1910, Mr. A. S. EDDINGTON, chief assistant in the Royal Observatory, Greenwich, has published an important paper discussing the proper motions of Professor Boss's catalogue from the standpoint of the hypothesis of two star-drifts. His purpose was to determine the directions, velocities, and relative proportions of the two drifts. He divided the sky into thirty-four areas, nearly equal, in such a way that each area in the northern hemisphere had an antipodal area in the southern hemisphere. The proper motions in right ascension and declination for each star were combined into the resultant or full proper motion, in a direction defined by position angle. The directions of proper motions of the individual stars in a given area were projected on the plane tangent to the celestial sphere at the center of that area. As antipodal areas would have parallel tangent planes, there were in effect but seventeen of these planes in all. For each area, the numbers of stars having proper motions in each of thirty-six position-angle sectors, 10° wide, were tabulated and plotted as vectors whose lengths were proportional to these *numbers* of stars in each sector. The *magnitudes* of the proper motions were not considered. The graphical representations of the proper motion directions in the seventeen double regions show not only the effect of the solar motion in a general drifting of the stars away from the apex, but such irregularities as would result from two preferential directions of the motions of the stars. Those regions of the sky which are so situated that they should show the maximum effect of preferential directions actually did show this peculiarity strongly, and those regions situated where the apparent effects should be a minimum did not, in fact, show any significant peculiarities in the existing apparent motions for the stars in those regions.

EDDINGTON'S main results are thus:—

The phenomena of two star-streams are well shown by the data in Professor Boss's Preliminary Catalogue.

About sixty per cent of the stars belong to what KAPTEYN has designated as Drift 1 and forty per cent to Drift 2.

The apparent directions and velocities of the two drifts are assigned by EDDINGTON, but these are necessarily affected by the motion of the solar system. He has deduced from the directions of the proper motions alone (neglecting the amounts of proper motion) that the apex of the Sun's way is at,—

$$\text{R. A.} = 267^{\circ}.3,$$
$$\text{Dec.} = +36\ .4,$$

Eliminating the effect of the Sun's motion, he obtains the position in the sky toward which one drift is moving as,—

$$\text{R. A.} = 94^{\circ}.2,$$
$$\text{Dec.} = +11\ .9;$$

the other drift necessarily moving toward the opposite point of the sky.

He deduces that the relative velocity of the two drifts is a shade more than twice the velocity of the solar motion with reference to the entire system of stars used.

His positions for the directions of the two drifts, called the vertices, or, more conveniently, the position of the vertex of the drifts, is in close agreement with positions determined by the eight or ten other investigations on the same subject based upon proper motions assigned by the older catalogues.

W. W. CAMPBELL.

RECENT ASTRONOMICAL PROGRESS.

The address given by the retiring president, H. P. HOLLIS, at the October meeting of the British Astronomical Association, furnishes a very readable account of the progress which has been made in astronomy in the past thirty or forty years. The address is of such a nature that one cannot make a brief summary of it; it is a summary in itself and must be read as a whole.

Toward the close of his remarks he asks the question, quoting from another speaker, "Which is the greatest discovery in astronomy?" The answer given by the other speaker was, "The one that is going to be made next." Mr. HOLLIS says, "The answer, I think, is only partially true, or rather, like other attempts at epigram, it assumes too much; but it is a good thing to keep in mind that we are not yet at the end, and that

there are more discoveries to be made, more inventions to be invented. It is sometimes useful to make guesses or estimates as to the next invention, and I suggest to you now that the next discovery may have some relation to magnetism. Fifty years ago AUGUST COMTE said we should never know anything of the material of the stars, and ten years later the spectroscope was applied in the way we are now familiar with. Is it too much to expect that an instrument will be invented by which we shall be able to observe or register the magnetic or electrical qualities of the stars? No one may be able to devise an instrument like this at the moment,—I think it necessary to say that I am not suggesting that wireless communication with *Mars* is one of the immediate possibilities,—but magnetism and astronomy seem to be combining in unexpected ways, and the idea I put to you does not seem unreasonable."

Mr. HOLLIS then speaks of Zeeman effect or change in the appearance of a spectrum which results from passing light through a magnetic field, and its application by HALE to the study of sun-spots, and of the investigations by Professor ERNEST BROWN of the possible effect of magnetic attraction between the Earth and the Moon, citing these as instances of the intimate connection between physics and astronomy.

He cited also the wonderful computation of the orbit of Comet Halley, which gave the predicted time of the comet's perihelion within three days of the actual time shown by the observations. "Dr. COWELL and Dr. CROMMELIN have assured themselves that there is no error in computation, and that the attractions of all matter that is known to exist have been taken into account; therefore since there is this difference of three days, there must be some forces now unknown at work. It will be curious if the computation of a comet's orbit should lead to the discovery of a new physical law."

Speaking of the difference in the class of work in astronomy, he says: "I think it may be said that people now look for causes rather than simply for facts. With no intention of belittling the workers of past days, I say that if you look through the indexes of the *Monthly Notices* or the reports of meetings of years back, you will find papers dealing with some academical point about instruments, or others of purely arithmetical character, with no suggestion of a physical conclusion, which

were received with enthusiasm. These things were certainly necessary and useful, but they seldom form part of the program now. People are impatient to see the facts of nature."

H. C. WILSON.

In the *Journal of the British Astronomical Association* for November, 1910, Mr. W. GOODACRE, F. R. A. S., reviews Dr. SEE'S article on the "Origin of the Lunar Surface Formations," which appeared in the February number of the *Publications* of the Astronomical Society of the Pacific, criticizing unfavorably the main points. He brings out a number of strong objections to the theory as outlined by Dr. SEE, and concludes as follows:—

"The effect of reading Dr. SEE'S article, so far as I am concerned, has been not to shake my faith in the volcanic theory, but rather to confirm it as being the most probable cause of the origin of the lunar surface formations."

In the same number Mr. SCRIVEN BOLTON describes his observations of certain wisp-like markings on the white equatorial belt of *Jupiter* during the last eight years. He finds that dark spots are situated on the average about 15° apart along the north and south edges of the equatorial zone, and that wisp-like markings extend diagonally from the north spots to the south ones, the wisps from alternate spots extending in different directions so that they intersect one another at the equator, forming something like a trellis-work structure. Sometimes one of two series of wisps is seen without the other. When both are visible the wisps are of a fainter character.

H. C. WILSON.

REMARKS ON THE COMETS WHICH HAVE APPEARED SINCE THE BEGINNING OF THE SIXTEENTH CENTURY, BY A. BORRELLY.[1]

M. BORRELLY has gathered some statistics which are not usually given, perhaps have never before been collected, concerning the discovery of comets, and draws some interesting conclusions. Of the 376 comets which have been discovered since the invention of the telescope, more than one third were discovered

[1] *Bulletin Astronomique*, October, 1910.

in France, Marseilles leading the list with sixty-four, and Paris following with forty-six comets to her credit. The following is a portion of the list of observatories credited with comet discoveries:—

Marseilles	64	Leipzig	7	Moscow	4
Paris	46	Slough	7	Bremen	3
Geneva	16	Cambridge	7	Copenhagen	3
Florence	15	Bologna	5	Echo Mountain	3
Lick	14	Heidelberg	5	Haarlem	3
Nice	12	Karlsruhe	5	Kiel	3
Berlin	12	Marlia	5	Limoges	3
Nashville	10	Milan	5	Nauen	3
Rochester	10	Strassburg	5	Princeton	2
Rome	10	Altona	4	Thaines	2
Göttingen	8	Bristol	4	Albany	2

More comets have been discovered in the second half of the year than in the first half, July being the banner month and May having the smallest number.

Nearly two thirds have been discovered in the eastern sky, and only a little over one third in the west. One would think *a priori* that the greater number of comets would be found west of the meridian, as that is undoubtedly the region of the sky most frequently explored.

More comets are discovered in the morning than in the evening, and when the Earth is proceeding from the summer to the winter solstice. This agrees with SCHIAPARELLI's discovery that the shooting stars which are connected with comets are more numerous in the morning and in the second half of the year.

Of the 376 comets 106 were periodic, nineteen having been observed at more than one return. Three comets are regarded as lost; sixty-five have been visible to the naked eye, and seven were seen in the daytime near the Sun.

BORRELLY calls attention to the fact that, as a rule, the appearance of a brilliant comet during the last half century has been followed by the discovery of one or more periodic comets, and collects a rather formidable list of examples of this "rule." The coincidences are rather striking, but they are probably only accidental coincidences, except as they resulted from the stimulus to search for new comets which is given by

the appearance of every brilliant one. M. BORRELLY thinks, however, that another conclusion is to be drawn, and that is, that the periodic comets are offshoots from the great ones, captured by the attraction of the planets, and that the great comets may be called the generators of the little ones.

H. C. WILSON.

TWO NEW MICROSCOPES FOR THE MEASUREMENT OF SPECTRA.

Dr. O. LOSHE describes in *Zeitschrift für Instrumenten Kunde,* June, 1910, a new spectrographic measuring engine by TOEPFER und SÖHNE, in which are embodied a number of interesting features. The machine as a whole is very massively constructed; the pitch of the screw is 0.5^{mm} and it is 25^{mm} (1 inch) in diameter, which will tend to reduce the wear resulting from use to a minimum. Tests of this screw have shown that it is very good. Ease of movement in the carriage is secured by ball-bearings. The microscope is provided with powers from 2½ to 160 diameters. The measures are recorded upon a strip of paper by a carefully worked-out registering apparatus. Fifteen keys are conveniently placed, making it possible to stamp a number of facts with regard to the line being measured in addition to the imprint of the measuring head. It is for instance possible to read off from the paper strip the whole number of revolutions, the parts of revolutions to 0.0001^{mm}, whether the line is a comparison or star line, its relative intensity in digits and tenths, whether the line measured is a band, whether middle or edges were measured, measure regarded as uncertain, and other details.

Another microscope on entirely different lines is described by LEISS in the *Deutsche Mechaniker-Zeitung* for November 15, 1910. The spectrogram is placed upon a fixed table, and the microscope is moved along on guides above the plate by a screw, which need not be accurately cut, as it is not used for measurement. For this an accurate glass scale divided to 0.1^{mm} is held by a gentle pressure scale side down upon the film of the plate to be measured. A reticle in the eye-piece makes it possible to read the scale directly to 0.01^{mm}. The measures on the spectral lines and the readings on the scale are thus made without removing the eye from the microscope. It would

seem that the engine could be improved by the addition of a tilting motion for greater ease in measuring, and an auxiliary slide on the plate-table for rapid orientation of the plate.

H. D. CURTIS.

NEW METHOD FOR DETERMINING A PHOTOGRAPHIC MAGNITUDE SCALE.

An interesting paper on this point is given by E. HERTZSPRUNG in *Astronomische Nachrichten,* No. 4,452, and consists in the employment of a coarse objective-grating in connection with extra-focal exposures. Hitherto objective-gratings have been employed for the purpose, possessing the advantage that the spectral character of the reduced image is not thereby altered. By taking photographs with and without the grating in front of the objective, a definite magnitude reduction is obtained from the known relation between the wires forming the grating and the grating interval. With extra-focal images, however, as suggested by HERTZSPRUNG, the spectra recorded by the grating at each side of the central image become round, and the colors overlap so that these images are in every way similar to ordinary extra-focal star images. The ratio of thickness of wire used for the grating and the interval between the wires is made unity, in which case the spectra of even order disappear and those of odd order reach their maximum intensity. In terms of the light incident on the grating, the central image then suffers a loss of intensity of $(1/2)^2 = 1^m.505$, while that of the spectra of the first order at each side of the central image is $\frac{1}{\pi^2} = 2^m.486$. The difference between the central image and the first order spectral image is then $0^m.981$, a step of convenient size. The advantages of having such a difference of magnitude taken on the same plate with exactly similar exposure conditions are obvious. H. D. CURTIS.

RESEARCHES ON THE RADIAL VELOCITY OF *SIRIUS.*

In *Astronomische Nachrichten,* No. 4,455, Dr. W. MÜNCH gives an extended investigation based upon thirty-three plates of *Sirius* taken with the III-prism spectrograph (Spectrograph IV) at Potsdam by Professors EBERHARD and LUDENDORFF in

the years 1901-1910. The paper is worked out with great thoroughness and a great deal of space is devoted to the discussion of all possible sources of error. On most of the earlier plates of the series everything was measured which could be measured at all; this is doubtless inadvisable. In the measures made at Lick Observatory of early-type stars far more accordant results are secured by measuring relatively few good lines instead of including a large number of lines of doubtful quality. In all fifty-six lines or blends were identified, belonging, with a few exceptions, to Cr, Fe, H, Mg, Ni, Sc, Ti, V, Y, Zr, and perhaps La and Mn. As so many lines were measured, some of which were very difficult and doubtful, a number of different hypotheses were applied to determine the resulting velocities by the rejection of certain lines or lines differing widely from the mean. Final values were adopted after consideration of the number and accuracy of the lines used and the inter-agreement of the individual measures of the lines.

Corrections were derived for the wave-lengths of some of the lines. I have compared these with corrections derived by Dr. BURNS from his measures of the Lick plates of the same star, and find quite wide divergencies in the corrections found by MÜNCH. It would seem that the material furnished by so small a number of plates would hardly be adequate for the trustworthy determination of such corrections.

The final values of the velocities, when allowance is made for the position in the orbit, range from -4.7^{km} to -16.8^{km}, a range which is disappointingly large, considering the ultra-refinement employed in the methods of reduction. Where comparison is possible with the Lick Observatory values, MÜNCH's values average about two kilometers larger negatively. The reason for the large range in values is not apparent; the observing records show that the prism temperatures of the Potsdam plates were very constant, and flexure seems not to have entered appreciably into the results; an attempt was made to find a systematic error depending on the hour-angle, but without result. Can the difficulty lie in the kind of plates used? Such stars as *Sirius* have been found to give far more accordant and trustworthy values when taken on plates of fine grain.

HEBER D. CURTIS.